IMAGING OF AN ASCENDING AORTIC ANEURYSM

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Outline

• Definition and epidemiology of ascending aortic aneurysm
• Anatomy of the thoracic aorta and classification
• Etiology and pathogenesis of ascending aortic aneurysm
• Clinical presentation and complications of ascending aortic aneurysm
• Different modalities for the diagnosis and evaluation of ascending aortic aneurysm
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• DDx of prominent aorta or aortic arch
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Definition and epidemiology of ascending aortic aneurysm

Localized dilatation of the aorta
50% over the normal diameter
Includes all three layers of the vessel (intima, media, adventitia)

Ascending aortic aneurysms arise anywhere from the aortic valve to the innominate artery

Incidence ➞ 3.6-6 cases per 100,000 pt. years

Males - 2x-4x more commonly than females
Anatomy of the thoracic aorta and classification

Aneurysm of the thoracic aorta can be classified into four anatomical categories

- Ascending aortic
- Aortic arch
- Descending aortic
- Thoracoabdominal

Aneurysms can be:
- Fusiform or
- Saccular

60%

Drawing of the thoracic aorta anatomy. The arrows show the percentage of the thoracic aneurysm that involves each anatomical segment.
Etiology and Pathogenesis of ascending aortic aneurysm

Pathophysiology:
  Cystic medial degeneration

Risk factors are:

• Aging
• Hypertension
• Atherosclerosis (infrequent cause).
• Smoking
• Bicuspid valve
• Inflammatory/infectious disorders (eg. giant cell arthritis, syphilitic aortitis)

• When occurs in young patients, think:
  ▪ Marfan syndrome
  ▪ Ehlers- Danlos syndrome
  ▪ Other familiar (eg. mutation in TGF beta receptor 2 gene)
  ▪ Takayasu arthritis: Young females/males

Clinical presentation and complications of ascending aortic aneurysm.

Most often asymptomatic
Heart failure due to aortic regurgitation
Myocardial ischemia or MI

Rare presentations due to mass effect:
• Hoarseness, hemidiaphragmatic paralysis
• Wheezing, cough, hemoptysis, dyspnea pneumonitis
• Dysphagia
• SVC syndrome
• Chest or back pain due to bone compression
• Thromboembolic episodes

Complications:
Dissection, leakage, rupture, acute aortic regurgitation
Different modalities for the diagnosis and evaluation of the ascending aortic aneurysm

- Chest X-ray
- Echocardiography
- CTA
- MRA
- Conventional angiography – seldom used our days
Possible findings on a CXR suggesting an ascending aortic aneurysm can be:

1. Widening of the mediastinum as a result of the prominence of the ascending aorta.
2. Mass effect (e.g. deviation of the trachea) can be an indicator of an ascending aortic aneurysm. There is no such finding in this companion patient's CXR.
Companion patient #1: CXR (Lateral view)

This is the companion patient (#1) lateral chest X-ray. Our findings are:

**Normal aortic arch**

**Normal distal ascending aorta**

**Dilated proximal ascending aorta**
DDx of prominent ascending aorta or aortic arch

**Congenital**
- Aortic arch anomaly (e.g., double aortic arch, right aortic arch
- PDA
- Tetralogy Fallot
- Coarctation of aorta; pseudocoarctation

**Acquired**
- Aneurysm of aorta
- Aortic regurgitation
- Aortic valve stenosis
- Aortitis (eg, syphilitic, giant cell, rheumatoid, Takayasu’s)
- Atherosclerosis (tortuosity, elongation, unfolding, and/or dilatation of aorta)
- Hypertensive heart disease
- Medial degeneration of aorta (eg, Marfan S., Ehlers-Danlos S.)
- Mediastinal mass simulating large aorta (eg, lymphoma)
Index Patient: History and findings

25 year old male presenting to the student clinic for a check up.

PMH: No

Findings: Hypertensive (SP 150 mmHg)

Transthoracic Echocardiography was performed to evaluate for hypertrophic left ventricle.

Findings: bicuspid valve and ascending aortic aneurysm.
Companion patient #2: on transthoracic echocardiography

This is a parasternal long-axis view in a companion patient (#2) showing a dilated aortic root and ascending aorta (white arrows).
Transthoracic Echocardiography (TTE) and Transesophageal Echocardiography (TEE) imaging of ascending aortic aneurysm

2003 ACC/AHA guidelines: Echocardiography for the diagnosis
2006 ACC/AHA guidelines: CT or MRI for quantification of dilatation

**TTE** →Preferred procedure. Effective for imaging the aortic root (e.g. In patients with Marfan syndrome), generally not be used for sizing thoracic aortic aneurysms.

**TEE** →Can visualize the entire thoracic aorta well, semi-invasive not favored for routine imaging.

Aortic root or ascending aortic diameter > 4 cm and bicuspid aortic valve → further evaluation (size morphology of root and ascending aorta) by echo, CT or MR yearly. So our index patient needs further CT or MR evaluation.
Index Patient: MRA imaging (levels of sinus of Valsalva and main pulmonary artery)

Multiplanar T1 and T2 weighted MR images were acquired in order to evaluate the aortic root and ascending aorta dilatation.

Axial view, C+, thoracic MRA
Level of the sinuses of Valsalva

Axial view, C+, thoracic MRA
Level of the main pulmonary artery
Index Patient: MRA imaging (levels of right pulmonary artery and aortic arch)

Axial view, C+, thoracic MRA
Level of the right pulmonary artery

Axial view, C+, thoracic MRA
Level of the aortic arch

PACS, BIDMC

Aortic diameters

PACS, BIDMC
Index Patient: MRA imaging (Sagittal view)

Findings: The aortic root and ascending thoracic aorta are dilated.

3D MR reformation of the aorta demonstrating a dilated ascending aorta.

Measurement of the ascending aorta was taken at the level of the left pulmonary artery (42.9 mm). Another measurement was taken at the level of the aortic arch (23.8 mm).
CTA images were then acquired to evaluate the aortic valve for calcification and the ascending aneurysm dimensions.

Aortic valve has a **bicuspid** morphology with a **tiny calcific speck**.

3D reformation, C+, Thoracic CTA

Axial view, C+, Thoracic CTA
At the aortic valve level, a maximum diameter of 27.7 mm is measured in the oblique view (bottom right corner).
At the Sinus of Valsalva level, a maximum diameter of 52.3 mm is measured in the oblique view (bottom right corner).
At the Sinus of Valsalva level, a maximum diameter of 48.33 mm is measured in the axial view.
Index Patient : CTA imaging

3D Reformations, Axial, Oblique views, C+, CTA
Aortic root level

At the aortic root level, a maximum diameter of 40,6 mm is measured in the oblique view (bottom right corner).
Index Patient: CTA imaging

3D Reformations, Axial, Oblique views, C+, CTA
Ascending aorta; level of right pulmonary artery

At the right pulmonary artery level, a maximum diameter of 39.4 mm is measured in the oblique view (bottom right corner).
Bicuspid aortic valve with fusiform dilatation of the ascending aorta with a maximum changes appreciated in the sinus of Valsalva.

### Maximum Diameter measurements in CTA and MRA (in mm).
The upper normal limit of Intra-luminal AAOD, is 35.6 for males in age group 20 to 40.*

<table>
<thead>
<tr>
<th>Level of Aorta</th>
<th>CTA</th>
<th>MRA</th>
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</thead>
<tbody>
<tr>
<td>Sinus of Valsalva</td>
<td>52.3</td>
<td>51</td>
</tr>
<tr>
<td>Aortic root</td>
<td>40.6</td>
<td>42</td>
</tr>
<tr>
<td>(Asc.) Right pulmonary artery</td>
<td>39.4</td>
<td>43</td>
</tr>
<tr>
<td>Aortic arch</td>
<td>-</td>
<td>24</td>
</tr>
<tr>
<td>(Des.) Right main pulmonary artery</td>
<td>23</td>
<td>-</td>
</tr>
</tbody>
</table>

*Song Shou Mao, MD, Nasir Ahmadi, MPH, Birju Shah, M.B.B.S, Daniel Beckmann, BS, Annie Chen, BS, Luan Ngo, BS, Ferdinand R Flores, BS, Yan lin Gao, MD, and Matthew J Budoff, M.D.
## Comparison between different modalities

<table>
<thead>
<tr>
<th></th>
<th>TTE</th>
<th>TEE</th>
<th>CXR</th>
<th>CTA</th>
<th>MRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st choice</td>
<td></td>
<td></td>
<td></td>
<td>Suitable for emergency</td>
<td>Time consuming (x2 CTA)</td>
</tr>
<tr>
<td>No contrast, no radiation exp.</td>
<td></td>
<td></td>
<td></td>
<td>Contrast, exposure to radiation (renal failure?)</td>
<td>Contrast, no radiation exp.</td>
</tr>
<tr>
<td>Non invasive</td>
<td></td>
<td></td>
<td></td>
<td>Non invasive</td>
<td>Non invasive</td>
</tr>
<tr>
<td>Low cost</td>
<td>Low cost</td>
<td>Low cost</td>
<td>Low cost</td>
<td>Expensive</td>
<td>Most expensive</td>
</tr>
<tr>
<td>Only images aortic root and ascending aorta</td>
<td>Provides additional info TTE</td>
<td>Not diagnostic (64% sensitivity of wid. Med. Sign. thoracic dis.)</td>
<td>Good in diagnosing and detecting dimensions (92% accuracy for all th.abs.)</td>
<td>Good in diagnosing and detecting dimensions</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>Images thrombus and calcification better</td>
<td>Images aortic root better</td>
</tr>
</tbody>
</table>

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Treatment

Medical → Beta blocker

Surgical: Index patient has a dilation of 51mm, one risk factor and a bicuspid valve, thus recommended for surgery

<table>
<thead>
<tr>
<th>Indication</th>
<th>Class of recommendation</th>
<th>Level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 50 mm for patients with Marfan syndrome*1</td>
<td>I</td>
<td>C</td>
</tr>
<tr>
<td>≥ 45 mm for patients with Marfan syndrome and risk factor</td>
<td>IIa</td>
<td>C</td>
</tr>
<tr>
<td>≥ 50 mm for patients with bicuspid valve and risk factor</td>
<td>IIa</td>
<td>C</td>
</tr>
<tr>
<td>≥ 55 mm for all other patients</td>
<td>IIa</td>
<td>C</td>
</tr>
</tbody>
</table>

The recommendations are valid irrespective of the severity of any concomitant aortic valve regurgitation.

*1 Patients with connective tissue disorders, Turner syndrome, and marfanoid patients who do not fulfill the Marfan criteria, are treated as Marfan patients.

Laplace law \( T = \frac{p r}{2 t} \)
- \( T \): Aortic wall tension
- \( P \): Intraluminal (blood) pressure
- \( r \): radius of aorta
- \( t \): aortic wall thickness

A decrease in blood pressure (b-blocker) decreases the aortic wall tension thus decreasing the aneurysms rate of growth (the vessel does not compensate by increasing its radius) and thus the possibility of dissection.
References


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